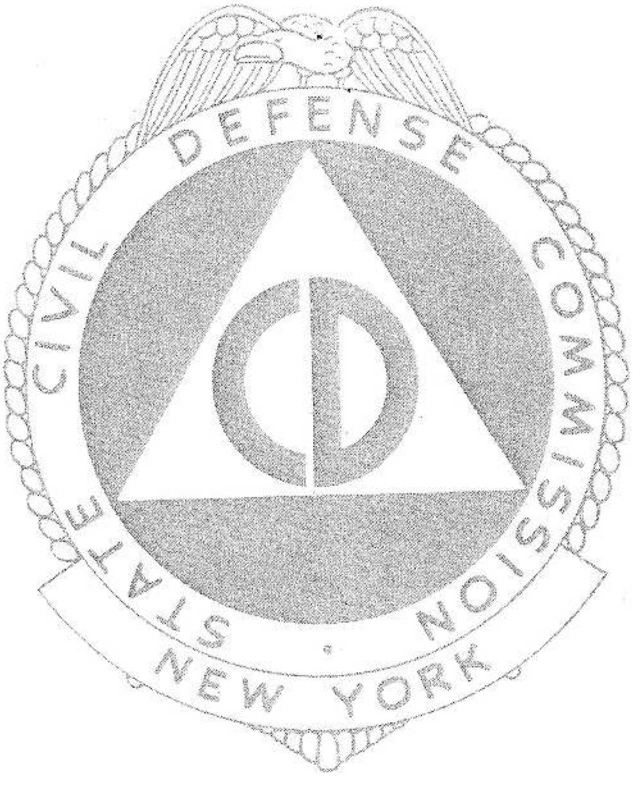
CIVIL DEFENSE
RESCUE AND RELIEF
OPERATIONS

FALLOUT EFFECTS MAPS



MARCH 1959

NEW YORK STATE CIVIL DEFENSE COMMISSION
124 E. 28TH STREET NEW YORK 16, N.Y.

INTRODUCTION

This is a paper about civil defense operations under conditions of fallout. It is written for local directors and their civil defense operating staff rather than for their Radiological Service personnel.

Much of the material about fallout written to date has been phrased in the technical language of the Radiological Service. This has been necessary; much more will be written as more is learned.

Before local directors and their staffs can make operational decisions under fallout conditions, they must know what actions the radiological situation will permit them to perform and where and when they can safely take various types of action.

The staff of the Commission has been working on this problem for the past year. Largely through the joint efforts of the Welfare Service and Radiological Service personnel we have developed some tools that translate the technical data into the language of operations.

These tools are called Fallout Effects Maps. They were presented and discussed at a Seminar for Directors on Radiological Defense early in February. In the National Civil Defense Exercise - OPERATION ALERT - 1959 - they will form the basis for the actions to be taken under the fallout conditions of an assumed attack. We must work with these tools, learn to use them and thereby learn how to lessen the effects of fallout on our people.

In post-attack rescue and relief operations civil defense directors must be prepared to cope with all three of the major effects of a nuclear attack - blast, heat and radiation. The manual on "Civil Defense Rescue and Relief Operations" published by the Commission in October 1958 dealt mainly with the problems resulting from blast and heat. This paper deals with some of the operational problems arising out of the third effect - radiation. It should be used in conjunction with the Rescue and Relief Manual and considered as a preliminary release of Chapter 22 of that Manual.

This does not rescind the paper entitled "Fallout Effects Maps" (January 1959) and the supplement thereto released in February with illustrations. Minor revisions have been made and the material has been reorganized for easier use.

C R Huebner

C. R. HUEBNER
Director

FALLOUT EFFECTS MAPS

1. A Fallout Effects Map is a map - or an overlay for a map - that shows the times and places at which gamma radiation from fallout will have a given effect on people under given conditions. It is a "question-answering map" that can be used in making operational decisions. Since civil defense personnel will need to know the answers to many questions about the effects of fallout radiation at various times, under various conditions of shelter, and in terms of various emergency conditions, they will need to have a number of fallout effects maps.

2. All Fallout Effects Maps are based on an isointensity-isochrone map that must be prepared by the Radiological Service technicians from reported data. The isointensity-isochrone map shows the points at which various intensities of gamma radiation were or were assumed to be present at one hour after a nuclear explosion. These intensities are dose-rates expressed in roentgens per hour and they are referred to as reference dose rates as they serve as the reference data from which other intensities and all dosages are calculated. These reference dose rate intensities are not dosages that would actually be received by people at various times and places. A sample isointensity-isochrone map is shown following page 4.

3. Even if a Director were shown the places in which people would receive equal dosages, he would then have to figure out what effects those dosages would have on people. In order to make operational decisions, a Director must be able to see the lines along which the

radiation dosages that people receive will have an equal effect on them. Within such boundary lines the effects of exposure to fallout radiation would be greater. These lines and areas are shown on Fallout Effects Maps.

4. Before we can translate the technical data found on the isointensity-isochrone map into material useful for operations, we must determine specifically what we want to know. For example, we may ask "Where will people be able to leave their shelters at two days after bomb burst?" This question cannot be answered until it is made more specific. The question must state when the people entered their shelters, the attenuation factor of the shelters, and the maximum permissible dosage that the Director (or State policy) has established for such people. Thus the above question might properly be phrased as follows: "Where will people who, from the time fallout began, have remained continuously in shelters with an attenuation factor of 10, be able to leave their shelters at 24 hours after bomb burst to live normally without exceeding a maximum permissible dosage of 75 r in a month or 200 r in a lifetime?"

5. That question can be answered by drawing a line on a Fallout Effects Map or acetate overlay. Within such a line the dosages received would be greater or departure time would have to be delayed longer. The same map can show, by lines, where people under the same conditions can leave their shelters at 12 hours, 36 hours, etc. Or the same question could be rephrased to ask where and when people can leave shelters with other attenuation factors or with other maximum permissible dosage standards. The answers could be given by other lines drawn on the same or on another map or map overlay.

Types of Fallout Effects Maps

6. Several types of Fallout Effects Maps can be prepared to show lines or areas requiring certain types of radiological defense measures. These types include:

a. Entry-Stay Times: When and where civil defense workers can enter to work a given number of hours without exceeding a given dosage.

b. Times to Leave Shelter to Resume Normal Living.

c. Evacuation Areas: The areas that must be evacuated at given times to avoid exceeding a given dosage of gamma radiation.

d. Return Times After Evacuation: The times after bomb-burst at which evacuees can safely return to their homes.

e. Death and Radiation Sickness Areas: The areas in which various percentages of the population with shelter of a certain radiation attenuation factor may be expected to die or become sick from receiving excessive exposures.

Basic Method of Preparing Fallout Effects Maps

7. The method of preparing a Fallout Effects Map will be stated briefly here; it is explained in some detail with reference to types of maps later in this paper. The steps are these:

a. Prepare an isointensity-isochrone map for the area. It may be one or more days after the attack before the Radiological Service staff has enough data to prepare this map. No Fallout Effects Maps can be drawn until an isointensity-isochrone map is completed.

b. Determine the maximum permissible dosage that is not to be exceeded.

c. Make assumptions or estimates of the extent to which the people were or will be exposed to the radiation present. These assumptions or estimates will include the degrees of shelter protection (attenuation factors) and the lengths of time that the people are exposed in and out of their shelters.

d. By using various graphs and tables published by the State Civil Defense Commission, locate various points on the isointensity-isochrone map at which the "fallout effect" will occur. The graphs and tables needed for many Fallout Effects Maps have been released in New York State Civil Defense Radiological Service Operations Manual OM 11-4 (17 Jan 1948 and 1949 Supplements). Specific reference to some of these papers is made in the following pages.

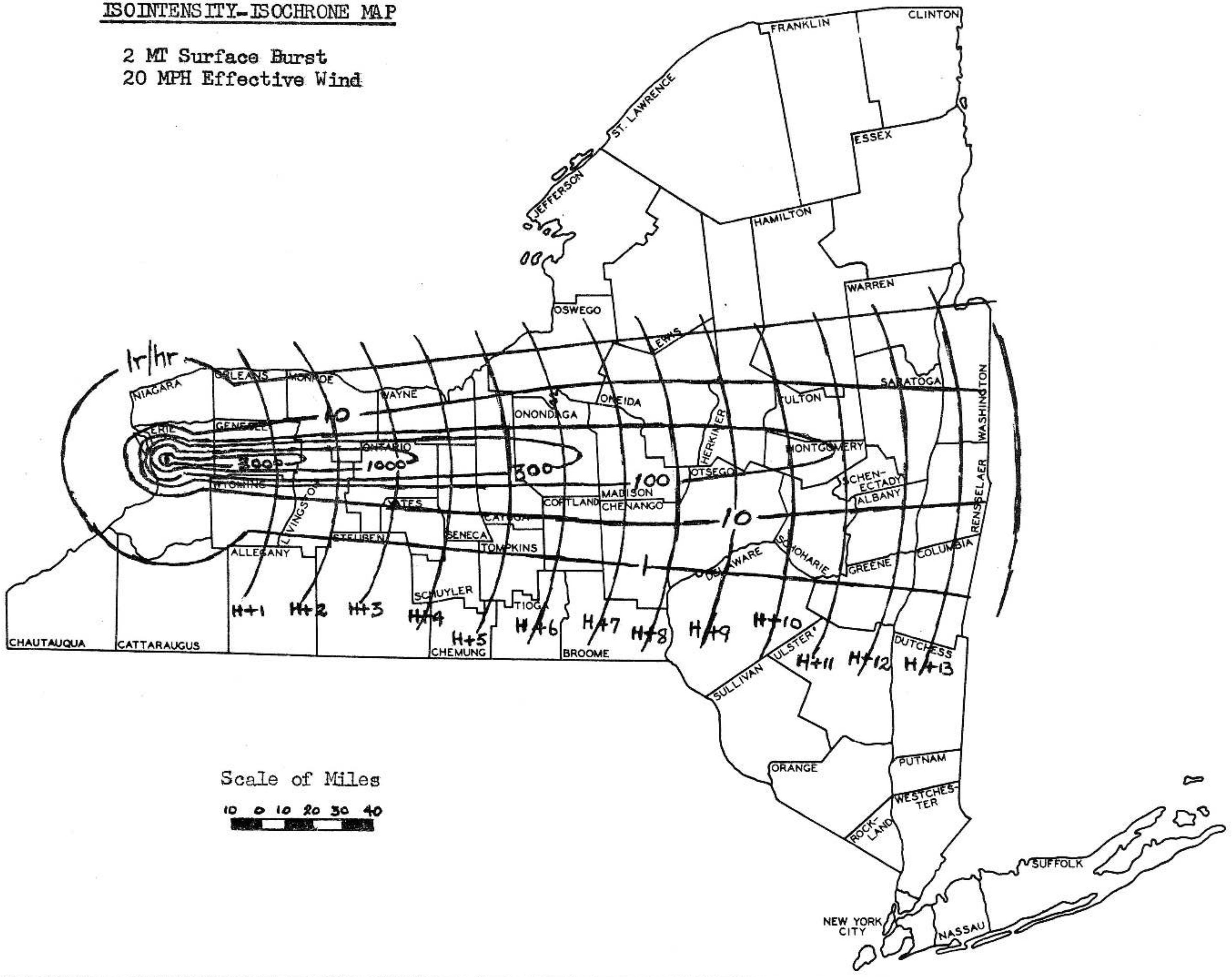
It is important to recognize that the figures shown on the tables and derived from the graphs are applicable to any size bomb and to any effective wind. Bomb-size and winds at various altitudes determine the size and shape of the isointensity-isochrone map. Once that is drawn, the location of points needed for plotting a fallout-effects map can be determined and then the lines can be quickly drawn.

e. Place an acetate overlay over the isointensity-isochrone map and plot the points located. Connect the plotted points with a smooth curve.

f. Place the overlay over a map which does not have isointensity-isochrone lines on it so that the areas in which the effects occur can be readily seen. The overlay then shows clearly a line or an area (or both) of operational significance.

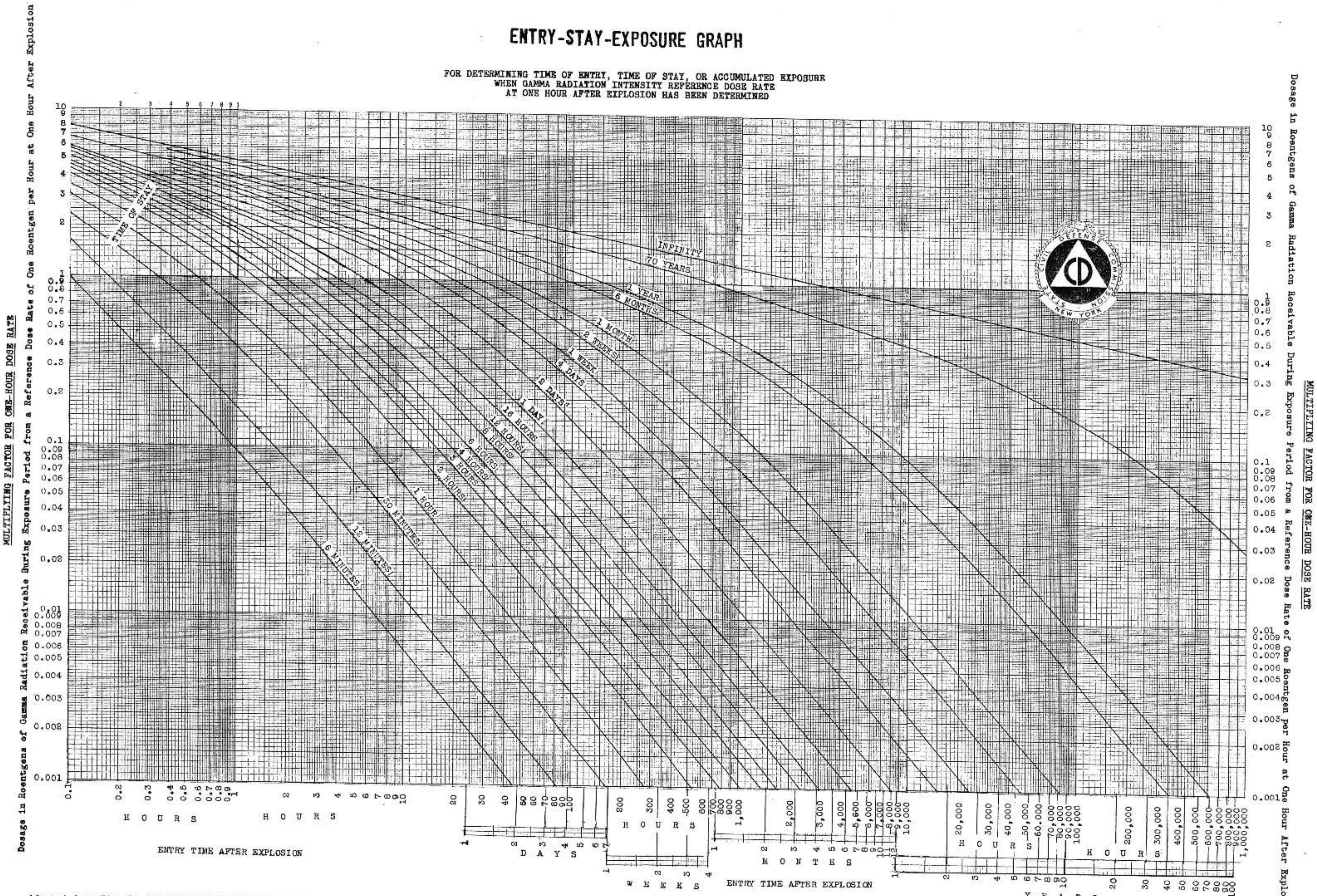
ISOINTENSITY-ISOCHRONE MAP

2 MT Surface Burst
20 MPH Effective Wind



ENTRY-STAY-EXPOSURE GRAPH

FOR DETERMINING TIME OF ENTRY, TIME OF STAY, OR ACCUMULATED EXPOSURE
WHEN GAMMA RADIATION INTENSITY REFERENCE DOSE RATE
AT ONE HOUR AFTER EXPLOSION HAS BEEN DETERMINED



Adapted from Fig. 12.107 "EFFECTS OF NUCLEAR WEAPONS" and from Fig. B.2 "RADIOLOGICAL DEFENSE"

CORRECTED 15 MARCH 1958

ENTRY-STAY TIMES - FALLOUT EFFECTS MAP

8. Fallout Effects Maps can be drawn which show the lines along which CD workers may enter at various times after bomb-burst to stay for various periods of times without exceeding allowable dosages for CD workers.

9. Use the "Entry-Stay Exposure Graph" published by the Commission on 15 March 1958 and included in OM 11-4. (Copy of graph attached).

10. Example: A Director wishes to know how far into the fallout area a "Class A" Civil Defense Worker may enter at 12, 24, 36, 48 and 72 hours, etc., after burst, to work for 8 hours without receiving more than 100 r dosage. He is able to send in workers from areas with no fallout so they are considered to be "previously unexposed" persons.

11. On the "Entry-Stay-Exposure Graph" the 12 hour entry time point is noted on the bottom line. Move up from that point until the 8 hour "Time of Stay" line is reached. Move across the graph to the left and read 0.3. Divide the allowable dosage of 100 r by 0.3; the result is the isointensity line (333 r/hr_1) at which a 100 r dosage will be received from H ≠ 12 hours to H ≠ 20 hours (an 8 hour time of stay). Note that the same dosage will be received along the 333 r/hr_1 isointensity line regardless of when the fallout began to come down. This is because it is assumed in this case that the fallout has all come down by H ≠ 12 hours or earlier and that the worker was not exposed during the earlier hours.

12. Note that this computation does not take into account the dosage the worker received while moving into and out of the radioactive area. This would be difficult to compute because of the various intensity areas he would pass through. However, we have assumed that he would be fully exposed during the 8 hours of work. It is possible that the dosage he would receive in travel would balance the dosage he would avoid by being partially shielded during some of his working time.

13. Place an acetate overlay over the isointensity-isochrone map. Locate the 333 r/hr$_1$ line on the map and trace it onto the overlay. The extent to which the 333 r/hr$_1$ line reaches downwind can be approximated in relation to the downwind extent of the isointensity contour lines already drawn on the map. It will reach somewhat less far downwind than a 300 r/hr$_1$ line which is usually drawn on an isointensity-isochrone map. The 330 r/hr$_1$ line is the entry-stay-time line along which a worker arriving at the time indicated may work for 8 hours without exceeding his allowable dosage of 100 r. Just inside the line he could work a little less than 8 hours.

14. The lines for the 24, 36, 48 and 72 hour and other times of entry would be determined by the same method.

ENTRY-STAY-TIME TABLES BASED ON STANDARD ASSUMPTIONS

15. The following tables furnish data for preparing radiation effects maps for stay times based upon the same entry times but for two different standard allowable exposure dosages.

- Allowable Dosage - 100 r
- Stay Time - 8 hours

Entry Time	Approximate r/hr$_1$ line
H + 12 hours	333
H + 24 hours	666
H + 36 hours	1000
H + 48 hours	1430
H + 72 hours	2175
H + 1 week	6060

- Allowable Dosage - 25 r
- Stay Time - 8 hours

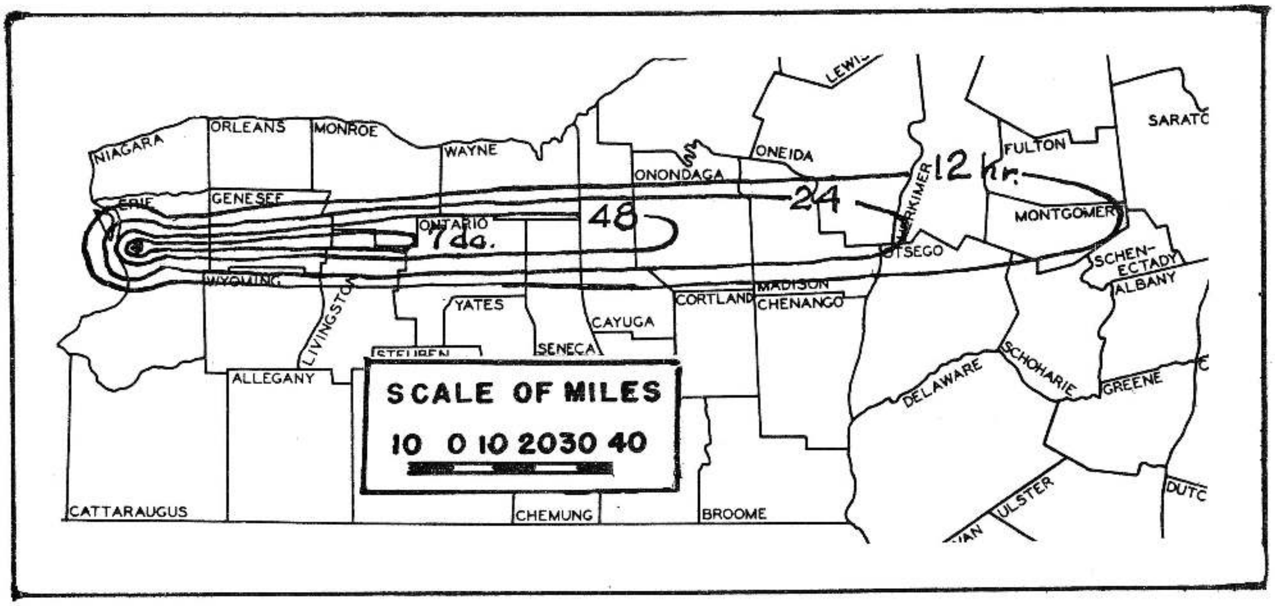
Entry Time	Approximate r/hr$_1$ line
H + 12 hours	83
H + 24 hours	167
H + 36 hours	250
H + 48 hours	357
H + 72 hours	544
H + 1 week	1515

16. If one wishes to know the lines along which one could work for 2 or 4 or any other number of hours at various times after burst (and after fallout is all down) without receiving more than a stated dosage, the same procedure can be used to develop a fallout effects map that will show this information graphically.

17. SAMPLE - ENTRY-STAY TIMES MAP OVERLAY

- Class "B" CD Workers
- Allowable dosage - 25 r in 8 hours

The lines are those along which a worker arriving at the time-after-burst indicated may work for 8 hours without exceeding 25r.



(This overlay is based upon the 2 MT - 20 MPH Effective Wind Isointensity-Isochrone Map shown following page 4.)

LEAVE SHELTER TIMES - FALLOUT EFFECTS MAP

18. A "Leave Shelter Time" line is a line on a map along which people, who have remained continously in shelter of a given attenuation factor since fallout began, may safely leave their shelter at a given time to live normally thereafter.

19. A map on which such lines are drawn is a Fallout Effects Map because it shows the points at which a given maximum permissible dosage can be avoided under given conditions. In an area within such a line, people would receive more than the maximum permissible dosage under the same given conditions.

20. ILLUSTRATION

Problem: to draw "leave shelter time" lines showing the times and places at which people who have been continuously in shelter with an attenuation factor of 10 from the time fallout began in their isochrone area may leave their shelters to live normally (receiving 50% of the outside radiation) without receiving more than 75 r in a month or 200 r in a 70 year lifetime.

21. METHOD

a. Using the graph "Guide to Evacuation Due to Excessive Gamma Radiation from Fallout", (copy attached) locate on the isointensity-isochrone map the reference dose rate intensities for several leave-shelter times (14 days, 7 days, etc.,) for each isochrone shown on the graph. The points for the problem noted above are approximately as follows:

LEAVE SHELTER TIMES

Shelter Attenuation Factor (AF)- 10

Time After Burst	ISOCHRONES				
	H ≠ 1/2 hr.	H ≠ 1 hr	H ≠ 6 hrs.	H ≠ 9 hrs.	H ≠ 12 hrs.
	Reference dose rate contour lines				
14 days	143	165	250	259	266
7 days	122	137	190	204	214
3 days	95	110	140	148	153
2 days	91	100	124	128	134
24 hours	77	85	102	106	109

Note that the 14 day "Leave Shelter Line" is identical with the Fallout Evacuation Line for shelter with an attenuation factor of 10. Just outside the line people need not evacuate to avoid the danger of excessive dosage; just inside it they must either evacuate or remain longer in shelter.

b. Plot on an overlay over the isointensity-isochrone map the points for each "leave shelter time." Draw lines connecting the points.

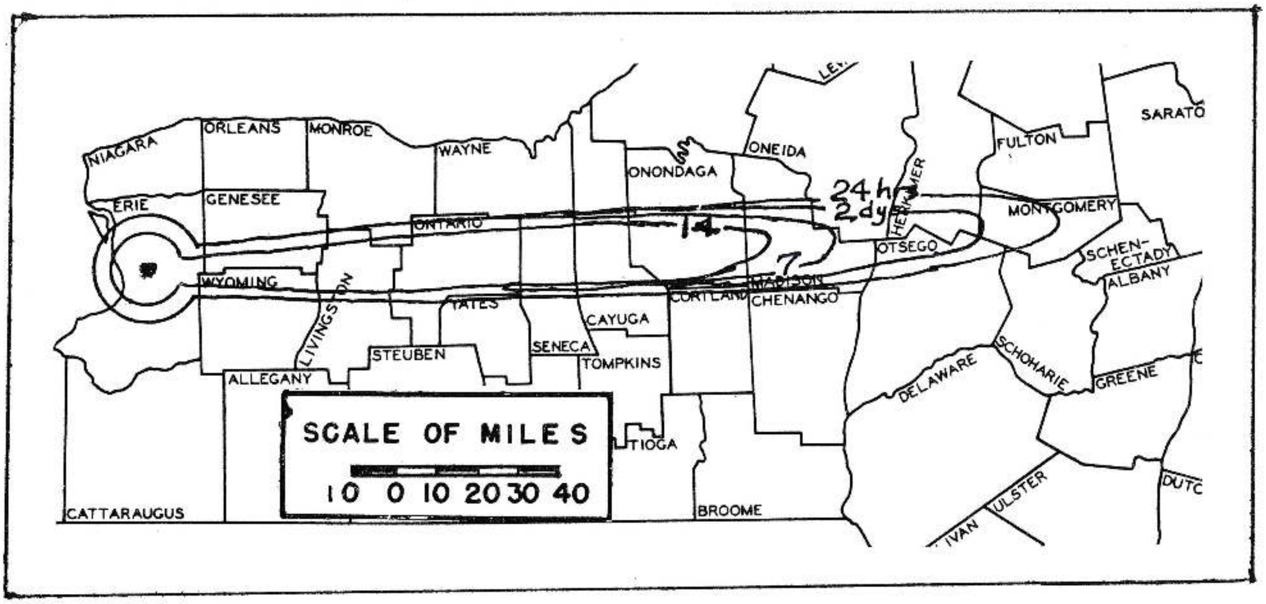
c. Place the overlay over a clean map (without isointensity-isochrone lines) so that the lines can be clearly seen.

22. Other "leave shelter lines" can be drawn as map overlays on the assumption of shelter attenuation factors of 100 or 1000, from data on the same graph "Guide to Evacuation Due to Excessive Radiation from Fallout." Computations for other shelter attenuation factors can be made by Radiological Service personnel from graphs and procedures published in OM 11-4.

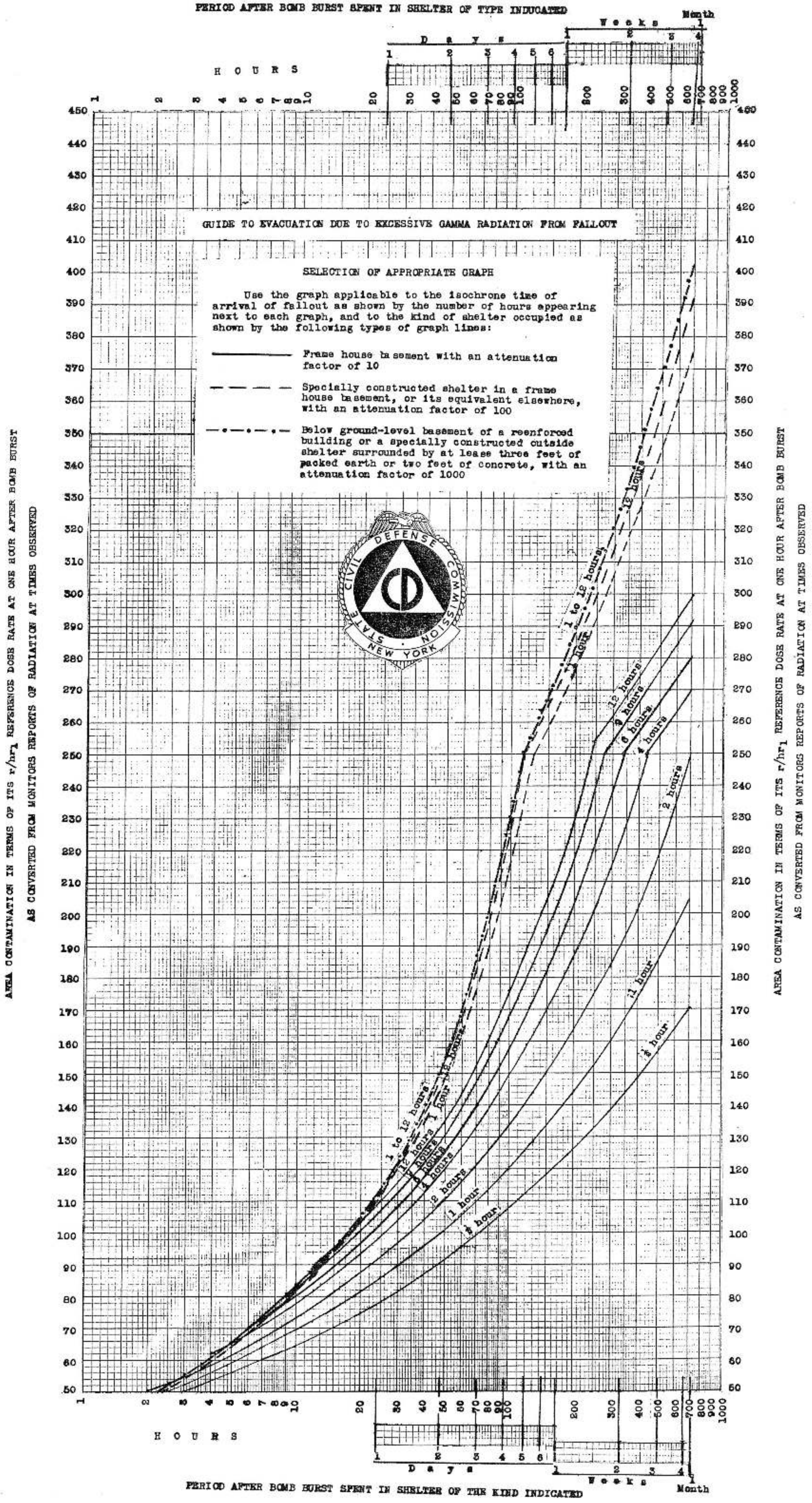
23. SAMPLE - LEAVE SHELTER TIMES MAP OVERLAY

- Maximum permissible dose - 75 r in a month or 200 r in a 70 year lifetime
- Shelter attenuation factor - 10
- Dosage after leaving shelter - 50% of full exposure

The lines are those along which persons may leave shelter at the indicated times after burst without exceeding the permissible dosage.



(This overlay is based upon the 2 MT - 20 MPH Effective Wind Isointensity-Isochrone Map shown following page 4).



GUIDE TO EVACUATION DUE TO EXCESSIVE GAMMA RADIATION FROM FALLOUT

SELECTION OF APPROPRIATE GRAPH

Use the graph applicable to the isochrone time of arrival of fallout as shown by the number of hours appearing next to each graph, and to the kind of shelter occupied as shown by the following types of graph lines:

————	Frame house basement with an attenuation factor of 10
— — —	Specially constructed shelter in a frame house basement, or its equivalent elsewhere, with an attenuation factor of 100
—•—•—	Below ground-level basement of a reenforced building or a specially constructed outside shelter surrounded by at lease three feet of packed earth or two feet of concrete, with an attenuation factor of 1000

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EVACUATION FROM FALLOUT AREAS FALLOUT EFFECTS MAP

24. Lines may be drawn on a Fallout Effects Map enclosing areas from which residents must be evacuated if they are to avoid receiving in excess of a given maximum permissible dosage.

25. Several factors must be assumed before the calculations can be made and the location of the lines determined. They are as follows:

a. Maximum Permissible Dosage for the General Population.

This is tentatively established in New York State as 75 r in a month or 200 r in a 70 year lifetime, whichever is applicable. The 75 r in a month figure is applicable up to the 250 r/hr_1 line for persons in shelters with an attenuation factor of 10 or better; above that intensity the 200 r - 70 year figure applies.

b. Shelter from Gamma Radiation before Evacuation.

It has been assumed that the average person in the State could find shelter with an attenuation factor of 10 (framehouse basement). This factor was used in calculations for OPAL - 58 and in current studies. Calculations may also be based on other attenuation factors such as 0 (no shelter), 100, 1,000, and "perfect."

c. Length of Stay in Shelter before Evacuation.

It is highly improbable that any general evacuation from a fallout area could be initiated before 7 days after bomb-burst; a delay until 14 days after burst may well be necessary to complete essential administrative and logistical arrangements. It takes time to gather and record radiological data and to develop an evacuation plan. Further, it is doubtful that the population would be able or willing to stay in present-day home shelters for more than 2 weeks. It is assumed that framehouse basements or better shelters will have been stocked in advance with food and the other facilities necessary for a continuous stay of two weeks. For calculating purposes it will be well to assume that the average person went into his shelter before fallout began and remained there continuously until an evacuation operation is started.

d. Dosage at Home after Leaving Shelter

The State has assumed that when people leave their shelters they will live and work normally rather than on a restricted basis. On this assumption, the dosage after leaving shelter has been computed at 50% of the dosage that would be received at full exposure. A "Fallout Evacuation Map" can be drawn on this assumption. The decrease in the fallout radiation that may be caused both by "weathering" - rain or snow - and by a later more rapid decay rate is not taken fully into account in the 50% assumption. For this reason it may be desirable to assume that the dosage received after leaving shelter would be a still smaller percentage of the dosage that would be received under conditions of full exposure. Such an assumption would result in lesser dosages, and the areas requiring the same radiological defense action would be reduced in size.

26. Method of Calculation and Preparation of Evacuation-from-Fallout Areas Map

a. Use the "Guide to Evacuation Due to Excessive Gamma Radiation From Fallout" (See OM 11-4). (Copy attached following page 10). It is based upon the assumptions that evacuation is from shelters with attenuation factors of 10, 100 and 1000; that there is exposure to only 50% of the outside radiation during normal living; and that it is desirable to avoid exposures in excess of 75 r in a month or 200 r in 70 years. The graphs will give points at each isochrone intersection of the isointensity lines at which evacuation is necessary under the above assumptions and factors.

Calculations based upon other factors, such as a lower dose rate in normal living or on a different maximum permissible dosage, can be made by Radiological Service personnel.

b. Place an acetate overlay over the isointensity-isochrone map. Locate the points on the isointensity lines at their intersections with each relevant isochrone.

c. Connect the points with a smooth curved line. This becomes the fallout effects map overlay for evacuation under the conditions stated above.

d. Place the overlay over a map without isointensity-isochrone lines and note the area inside the line. The line on the overlay bounds the area that must be evacuated.

Evacuation Tables Based on Certain Standard Assumptions:

27. EVACUATION DUE TO FALLOUT - AFTER 2 WEEKS IN SHELTER

- Maximum Permissible Dosage - 75 r month or 200 r - 70 years.
- Evacuation Time - H + 14 days.
- Attenuation Factors - 10, 100, 1000 and "perfect".
- Normal living after leaving shelter - 50% full exposure
- Areas within which evacuation is necessary are shown by the indicated r/hr_1 reference dose rate isointensity lines.

Isochrone	SHELTER ATTENUATION FACTOR			
	10	100	1000	Perfect
	Reference Dose Rate Contour Lines (r/hr_1)			
H + ½ hr.	143	309	328	330
H + 1 hr.	165	313	328.7	330
H + 2 hrs.	190	316	329	330
H + 4 hrs.	223	318	329.3	330
H + 6 hrs.	250	320	329.5	330
H + 9 hrs.	259	322	329.7	330
H + 12 hrs.	266	322	329.7	330

28. EVACUATION DUE TO FALLOUT AFTER 7 DAYS IN SHELTER

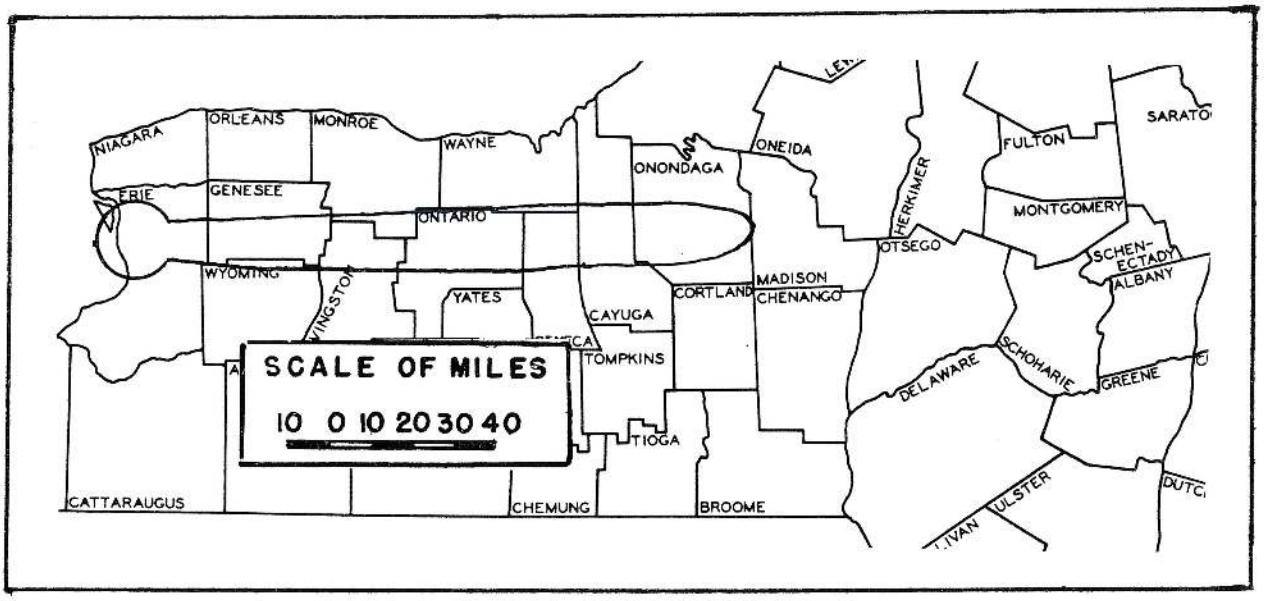
- Same assumptions as in Table above except evacuation at H + 7 days

Isochrone	SHELTER ATTENUATION FACTOR			
	10	100	1000	Perfect
	Reference Dose Rate Contour Lines (r/hr_1)			
H + ½ hr.	123	264	276	277
H + 1 hr.	137	266	276	277
H + 2 hrs.	156	268	276	277
H + 4 hrs.	176	270	276	277
H + 6 hrs.	190	271	277	277
H + 9 hrs.	204	272	277	277
H + 12 hrs.	215	273	277	277

29. SAMPLE - EVACUATION FROM FALLOUT AREAS MAP OVERLAY

- Maximum permissible dosage - 75 r in a month or 200 r in a 70 year lifetime
- Shelter attenuation factor - 10
- Evacuation at H + 14 days
- Normal living after leaving shelter (if not evacuated) - 50% of full exposure

The line encloses the area that must be evacuated if residents are to avoid an excessive dosage.



(This overlay is based upon the 2 MT - 20 MPH Effective Wind Isointensity-Isochrone Map shown following page 4).

RETURN TIMES AFTER EVACUATION FROM FALLOUT

30. Return Time Fallout Effects Maps are map overlays which show the areas to which persons who have been evacuated can return to their homes at various times after bomb-burst without receiving a total dosage in excess of the specified maximum permissible dosage.

31. Each Return Time Map Overlay must be related to a specific Evacuation Map overlay; it must be based on the same shelter standards and assumptions of:

- Maximum permissible dosage,
- Attenuation factor of shelter,
- Length of stay in shelter.

32. In addition, a Return Time Map must take three other factors into consideration:

--- Dosage received in evacuation travel time
--- Dosage during stay in reception area,
--- Dosage after return to evacuated area.

Dosage Received in Travel Time

33. To be on the safe side, it is assumed that the dosage received in a given number of hours of evacuation travel time is the same as would be received during the same number of hours in the area from which the persons are being evacuated. Thus the dose rate or intensity in the evacuation area at the time the movement starts is multiplied by the number of hours that it takes to reach the reception area.

34. For situations such as those assumed to have been present during OPAL - 1958 the State staff has been using a 4-hour travel time figure in computing its graphs and illustrations.

Dosage Received in the Reception Area

35. The dosage that an evacuee would receive while living in the reception area will depend on the intensity of gamma radiation in the area while he is there, on the length of his stay, and on the extent to which he is shielded during his stay. The State staff has assumed that an evacuee would "live normally" while in the reception area; that is, he would not live in a shelter but would spend part of his time indoors and part outside. On this basis, it is assumed that an evacuee would receive 50% of the outside radiation present (50% of the calculated maximum possible exposure).

Dosage After Return Time to the Evacuation Area

36. Again, the dosage that an evacuee would receive after his return will depend on the intensity of the radiation in the evacuation area from the time of return until he leaves the area or dies, and on the amount of shielding from the radiation present during that time period.

37. In order to estimate the time of safe return, the State staff has again assumed that people will receive 50% of the outside radiation at their homes. And it has assumed that evacuees will continue to live in their home areas from the time of return until 70 years after bomb-burst. The latter assumption obviously will not apply to adults nor to people who move away or die earlier from natural causes. It may well apply to children who will make up a significant percentage of any evacuee group. Computations can be based, of course, on any other assumption.

Method of Calculation and Preparation of Return-Times-After-Evacuation Map

38. Use the following graphs prepared by the State Civil Defense Commission and released in early 1959 in Chapter VIII of OM 11-4. (Copies are attached). Similar graphs, based on other assumptions, can be prepared as explained in that chapter.

a. "Permissible Return Times to Evacuated Areas from Reception Area Free of Radiation Contamination."

This graph can be used for reception areas with no radiation (0 r/hr_1).

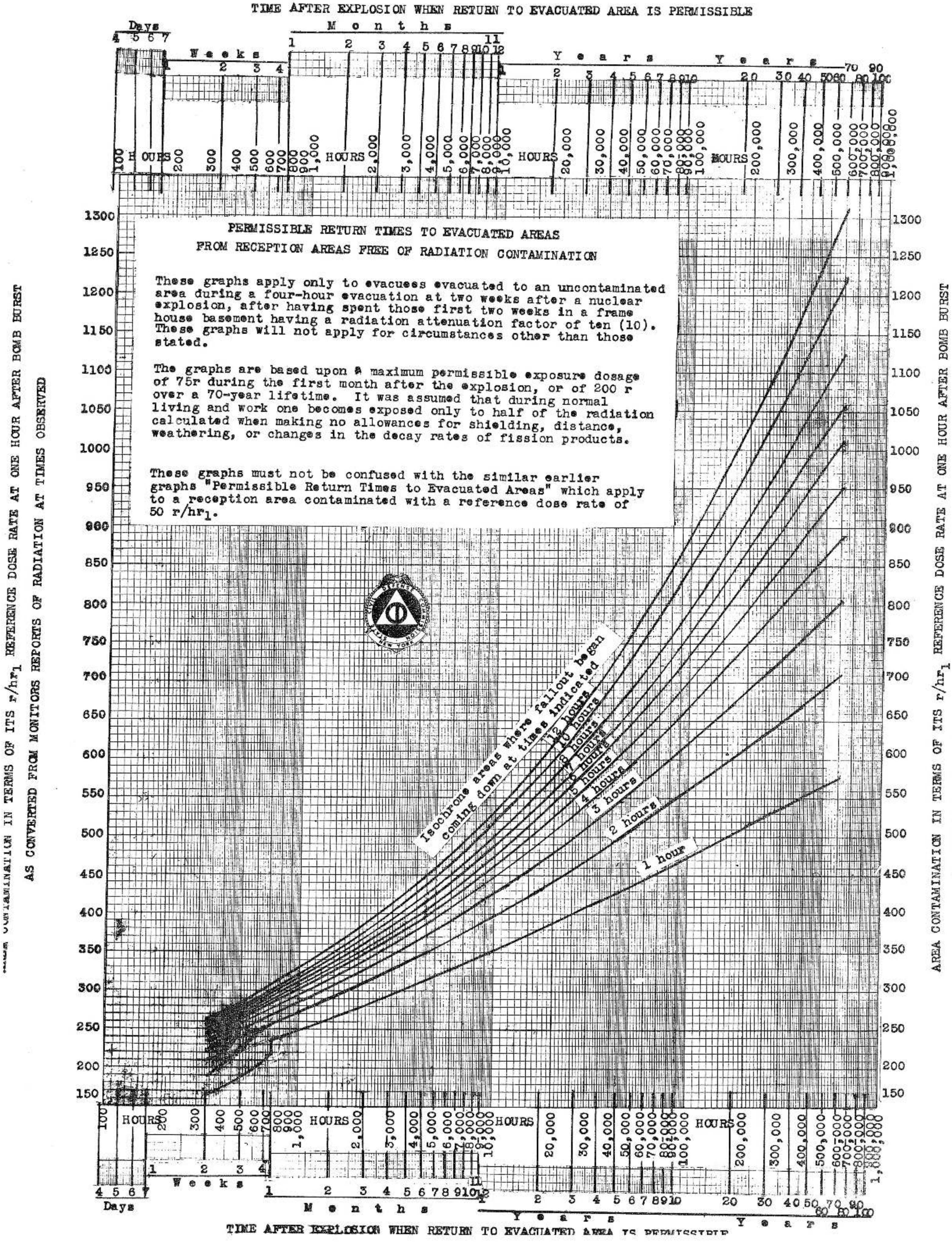
b. "Permissible Return Times to Evacuated Areas."

This graph can be used only if it is assumed that the evacuation began at H + 14 days, that the attenuation factor in the evacuation area before leaving home was 10, that the travel time was 4 hours, and that the reception area had an intensity of 50 r/hr_1.

39. Place an acetate overlay over the isointensity-isochrone map and locate on it the points of intersection of the isointensity lines at each relevant isochrone for standard return times such as 6 months, 1, 5, 10, 20 and 70 years (never). Certain of these isointensity line values are read from the graphs in 38 a or b above. For other situations other graphs can be prepared as indicated above.

40. Connect the points on the overlay, with smooth curved lines for each return time.

41. Place the overlay over a map without isointensity-isochrone lines and note the areas that fall between the lines. The area inside the 70 year (never) line is the area to which people cannot return until 70 years or more after bomb-burst without receiving more than the maximum permissible dosage. The area between the 70 year line and the 20 year line is the area in which people can return at times between 20 years and 70 years after bomb-burst, etc. See also paragraph 37 relative to persons of different ages, and paragraph 25 d relative to possible shortening of calculated return times due to heavier weathering and more rapid decay than considered.



PERMISSIBLE RETURN TIMES TO EVACUATED AREAS
FROM RECEPTION AREAS FREE OF RADIATION CONTAMINATION

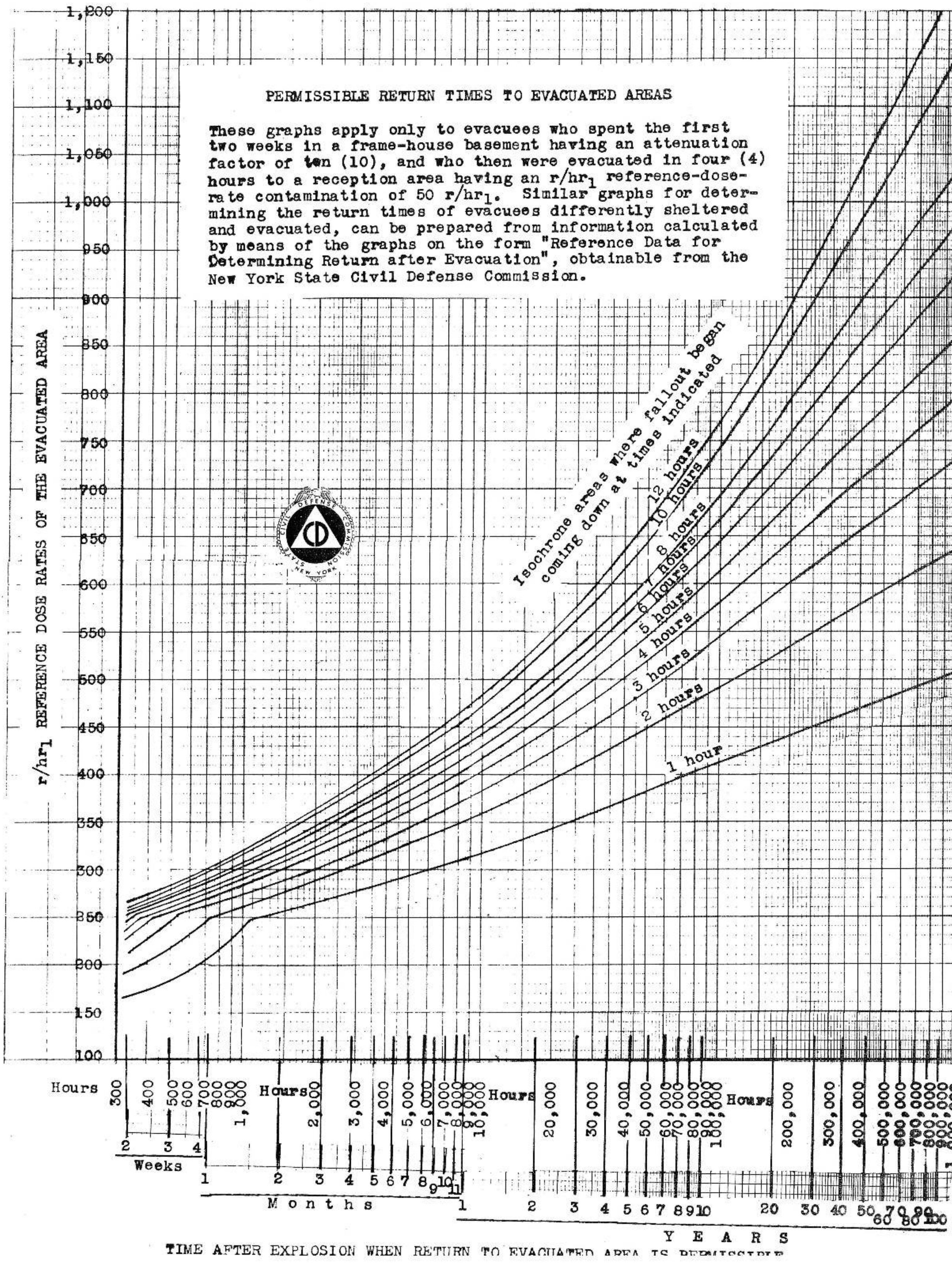
These graphs apply only to evacuees evacuated to an uncontaminated area during a four-hour evacuation at two weeks after a nuclear explosion, after having spent those first two weeks in a frame house basement having a radiation attenuation factor of ten (10). These graphs will not apply for circumstances other than those stated.

The graphs are based upon a maximum permissible exposure dosage of 75r during the first month after the explosion, or of 200 r over a 70-year lifetime. It was assumed that during normal living and work one becomes exposed only to half of the radiation calculated when making no allowances for shielding, distance, weathering, or changes in the decay rates of fission products.

These graphs must not be confused with the similar earlier graphs "Permissible Return Times to Evacuated Areas" which apply to a reception area contaminated with a reference dose rate of 50 r/hr$_1$.

PERMISSIBLE RETURN TIMES TO EVACUATED AREAS

These graphs apply only to evacuees who spent the first two weeks in a frame-house basement having an attenuation factor of ten (10), and who then were evacuated in four (4) hours to a reception area having an r/hr_1 reference-dose-rate contamination of 50 r/hr_1. Similar graphs for determining the return times of evacuees differently sheltered and evacuated, can be prepared from information calculated by means of the graphs on the form "Reference Data for Determining Return after Evacuation", obtainable from the New York State Civil Defense Commission.



RETURN TIME TABLES BASED ON STANDARD ASSUMPTIONS

42.

Return Times After Evacuation Due to Fallout - Reception Area of No Contamination (0 r/hr_1)

- Maximum permissible dosage 75 r in a month or 200r in 70 years
- Evacuation Time - H + 14 days - Attenuation Factor 10
- Normal living in reception area - 50% full exposure
- Normal living after return - 50% full exposure
- Evacuation travel time - 4 hours
- Reception area intensity - 0 r/hr_1 (None)

Isochrone	RETURN TIMES					
	6 months	1 year	5 years	10 years	20 years	70 years (Never)
	Reference Dose Rate Contour Lines					
H + ½ hr.	278	306	371	399	434	475
H + 1 hr.	310	345	427	466	503	575
H + 2 hrs.	348	389	497	551	603	710
H + 3 hrs.	370	417	544	608	672	807
H + 4 hrs.	384	437	578	652	733	886
H + 5 hrs.	395	451	603	683	770	950
H + 6 hrs.	404	465	629	717	815	1011
H + 9 hrs.	424	500	685	795	900	1135
H + 12 hrs.	448	518	735	860	1000	1310

43.

Return Times After Evacuation Due to Fallout -

Reception Area of 50 r/hr_1.

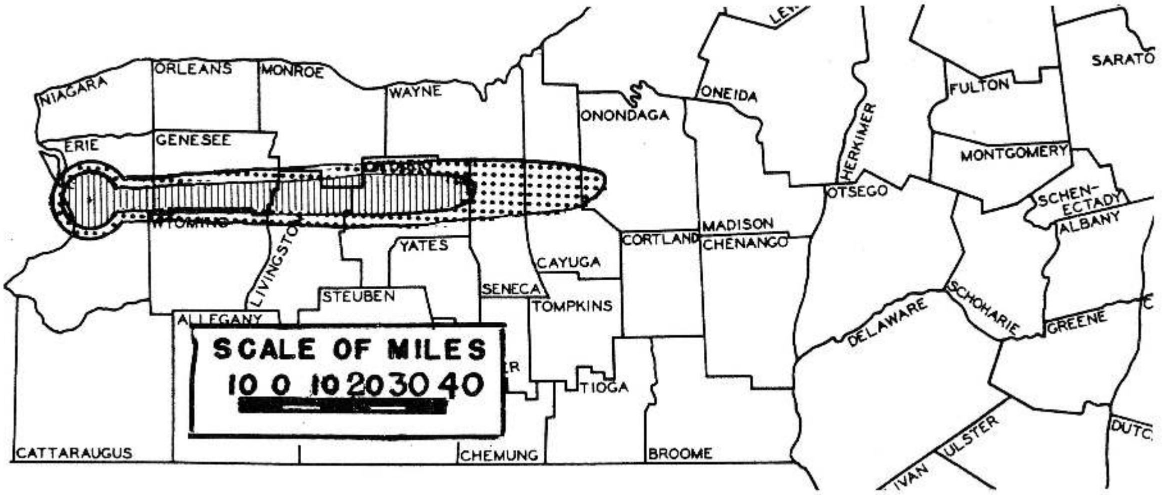
- Maximum Permissible dosage - 75 r in a month or 200 r in 70 years
- Evacuation Time - H + 14 days - Attenuation Factor - 10
- Normal living in reception area - 50% full exposure
- Normal living after return - 50% full exposure
- Evacuation travel time - 4 hours
- Reception Area intensity - 50 r/hr_1

Isochrone	RETURN TIMES					
	6 mos.	1 year	5 years	10 years	20 years	70 yrs. (Never)
	Reference Dose Rate Contour Lines					
H + 1/2 hr.	235	259	313	338	360	403
H + 1 hr.	290	312	378	406	432	488
H + 2 hrs.	322	351	440	483	526	602
H + 3 hrs.	338	377	480	530	588	689
H + 4 hrs.	355	394	508	568	632	747
H + 5 hrs.	365	407	530	598	670	805
H + 6 hrs.	375	423	558	628	707	863
H + 9 hrs.	400	450	610	710	800	1010
H + 12 hrs.	418	454	650	750	870	1120

44. SAMPLE - RETURN TIMES AFTER EVACUATION FROM FALLOUT AREAS - MAP OVERLAY

- Maximum permissible dosage - 200 r - 70 years
- Shelter attenuation factor - 10
- Evacuation at H+14 days
- Evacuation travel time - 4 hours
- Reception area intensity - 50 r/hr_1
- Normal living in reception area - 50% of full exposure
- Normal living after return -50% of full exposure

The lines enclose areas to which evacuated persons may return at the indicated times after burst without exceeding the permissible dosage of 200 r in 70 years.



RETURN TIMES

▦ Return at 1 year to 70 years

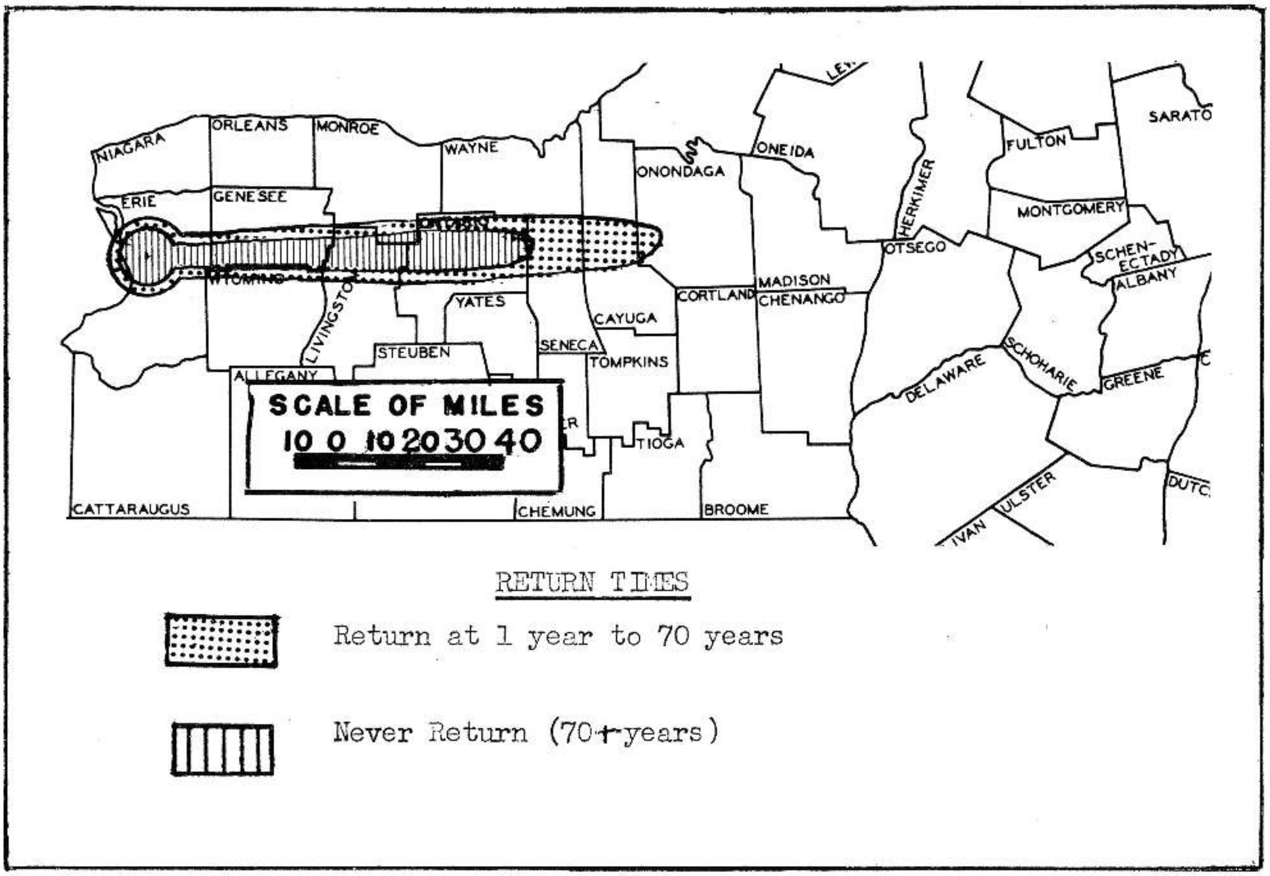
▥ Never Return (70+years)

(This overlay is based on the 2 MT - 20 MPH Effective Wind Isointensity-Isochrone Map shown following page 4).

44. SAMPLE - RETURN TIMES AFTER EVACUATION FROM FALLOUT AREAS - MAP OVERLAY

- Maximum permissible dosage - 200 r - 70 years
- Shelter attenuation factor - 10
- Evacuation at H+14 days
- Evacuation travel time - 4 hours
- Reception area intensity - 50 r/hr_1
- Normal living in reception area - 50% of full exposure
- Normal living after return -50% of full exposure

The lines enclose areas to which evacuated persons may return at the indicated times after burst without exceeding the permissible dosage of 200 r in 70 years.



(This overlay is based on the 2 MT - 20 MPH Effective Wind Isointensity-Isochrone Map shown following page 4).

DEATH AND RADIATION SICKNESS FALLOUT EFFECTS MAP

45. A Fallout Effects Map can be prepared to show the lines along which, and the areas within which, various percentages of the resident population may be expected to die or to become sick due to excessive doses of radiation, if they had remained in shelters of given attenuation factors for given periods of time.

46. Before preparing such a map it is necessary to have established standards which give the percentages of persons who are expected to die or become sick as the result of receiving a given dosage within a given period of time. Data provided by the AEC and OCDM are fairly definite with reference to the effects of acute exposure, i.e., exposure within a period of approximately 24 hours. The data on the effects of chronic exposure (long exposure to relatively smaller dosages) are vague. The State staff believes that a higher percentage of persons will die (or become sick) from continuing to being exposed to radiation from fallout after an initial 24 hour period. It does not have official data on which to base these higher percentages.

47. At the present time, and for exercise purposes only, data on 24 hour exposures only will be used as the basis for map preparation. In using this data, it should be recognized that the numbers of casualties certainly will be higher, and probably much higher and the areas on the map larger, in an actual fallout situation. This is because people will continue to be exposed to dangerous radiation after H ≁ 24 hours. When more data is received from the Federal government, it will be included in guidance material for local Directors.

48. The following tabulation gives various death and sickness percentages resulting from acute exposure to gamma radiation from fallout. These figures are tentative and for exercise purposes only.

Percentages of Death and Radiation Sickness from Various Dosages of Gamma Radiation Received in the First 24 Hours after Burst

Accumulated Dosage	Death %	Serious Radiation Sickness With Recovery
700 r +	$97\frac{1}{2}$	$2\frac{1}{2}$
450 r to 700 r	67	33
250 r to 450 r	$37\frac{1}{2}$	$62\frac{1}{2}$
100 r to 250 r	5%	95
Below 100 r	-	$2\frac{1}{2}$

49. Method of Calculation and Preparation of a Map Based on Shelter With an Attenuation Factor of 10, during the First 24 Hours After Burst.

a. Prepare an isointensity-isochrone map.

b. Assume an attenuation factor of 10 for the shelter of the average of the population.

c. For each relevent isochrone line (up to about H + 6 hours) calculate the dosage that would be received between the time fallout began at the isochrone line and H + 24 hours from a reference dose rate of one roentgen per hour at one hour after burst. Divide the result by 10. These calculations can be made on a radiological calculating device or they can be determined from the graph "Dosages in Roentgens to Infinity from a Radiation Intensity of One Roentgen Per Hour as of One Hour After Burst (r/hr_1)" (illustrated in OM 11-4).

d. Divide the dosage figures in c above into the standard exposure dosages of 700 r, 450 r, 250 r, and 100 r. The results are the r/hr_1 reference dose rates of the isointensity lines which, at their intersections with the isochrone lines, determine the points on the map at which these dosages will be received in the first 24 hours after burst.

e. Place an acetate overlay over the isointensity-isochrone map, locate on it the points determined in d above, and draw smooth curves through these points. These are Death and Radiation Sickness lines for the conditions stated.

f. Place the overlay over a map without isointensity-isochrone lines and note the areas inside of, and between, the Death and Radiation Sickness lines drawn.

g. Calculate the number of persons who may be expected to die or become seriously sick in the delineated areas, as the result of first-24 hour exposures, by referring to the percentage table shown above. These numbers probably will be low, for the reasons stated earlier, unless the exposure is terminated or greatly reduced at H + 24 hours.

50. Table of Reference Dose Rates Based on Standard Assumptions Relating to Death and Radiation Sickness, for Exercise Purposes Only.

Basic Assumptions

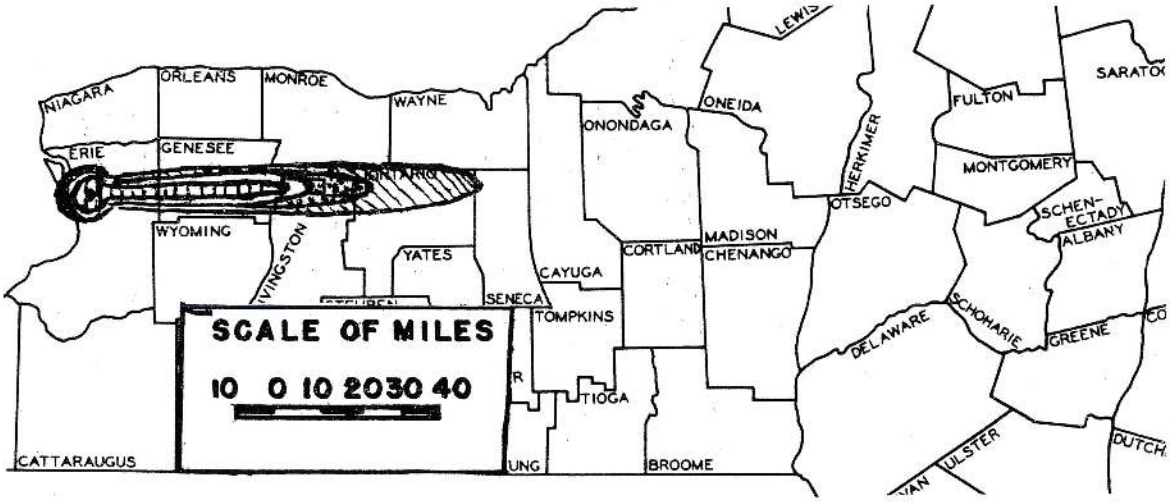
- Shelter Attenuation Factor - 10.
- Standard Accumulated Dosages 700 r, 450 r, 250 r, 100 r.
- Isointensity Lines at which these Dosages will be received Between H + 1 and H + 24 hours only.

Isochrone	Accumulated Dosages			
	700 r	450 r	250 r	100 r
	r/hr_1 Reference Dose Rates			
H + ½ hr.	2265	1456	803	323
H + 1 hr.	2953	1900	1054	421
H + 2 hrs.	-	2631	1461	584
H + 3 hrs.	-	-	1824	729
H + 4 hrs.	-	-	-	869
H + 5 hrs.	-	-	-	990
H + 6 hrs.	-	-	-	1150

51. SAMPLE - DEATH AND RADIATION SICKNESS MAP OVERLAY

- Effects from accumulated dosages of gamma radiation received in acute exposures only in the first 24 hours after burst.
- Shelter attenuation factor - 10
- Standard accumulated dosages, 700r, 450r, 200r, and 100r.

The lines enclose areas in which the residents may be expected to receive lethal doses or doses that will result in serious radiation sickness in the percentages given in the table.



Key	Accumulated Dosages	Death	Serious Radiation Sickness with Recovery
▥	700r +	97½%	2½%
▭	450r to 700r	67 "	33 "
░	250r to 450r	37½"	62½"
▨	100r to 250r	5%	95 "
	Below 100 r	—	2½"

(This overlay is based on the 2 MT - 20MPH Effective Wind Isointensity Isochrone Map shown following page 4).

ILLUSTRATIONS OF OTHER FALLOUT EFFECTS MAPS

52. The illustrations in the previous pages are based on the surface burst of a single relatively small H-Bomb. It was assumed that there was no overlapping fallout pattern and that an effective wind of 20 miles per hour blew the radioactive dust in such a way that the isointensity lines would be even and smooth. These illustrations are valuable because they make it possible to see the process of preparing Fallout Effects Maps.

The maps which follow show the kinds of fallout patterns that must be expected - overlapping fallout from a multiple bomb attack and highly irregular fallout patterns resulting from variable winds and differing terrain.

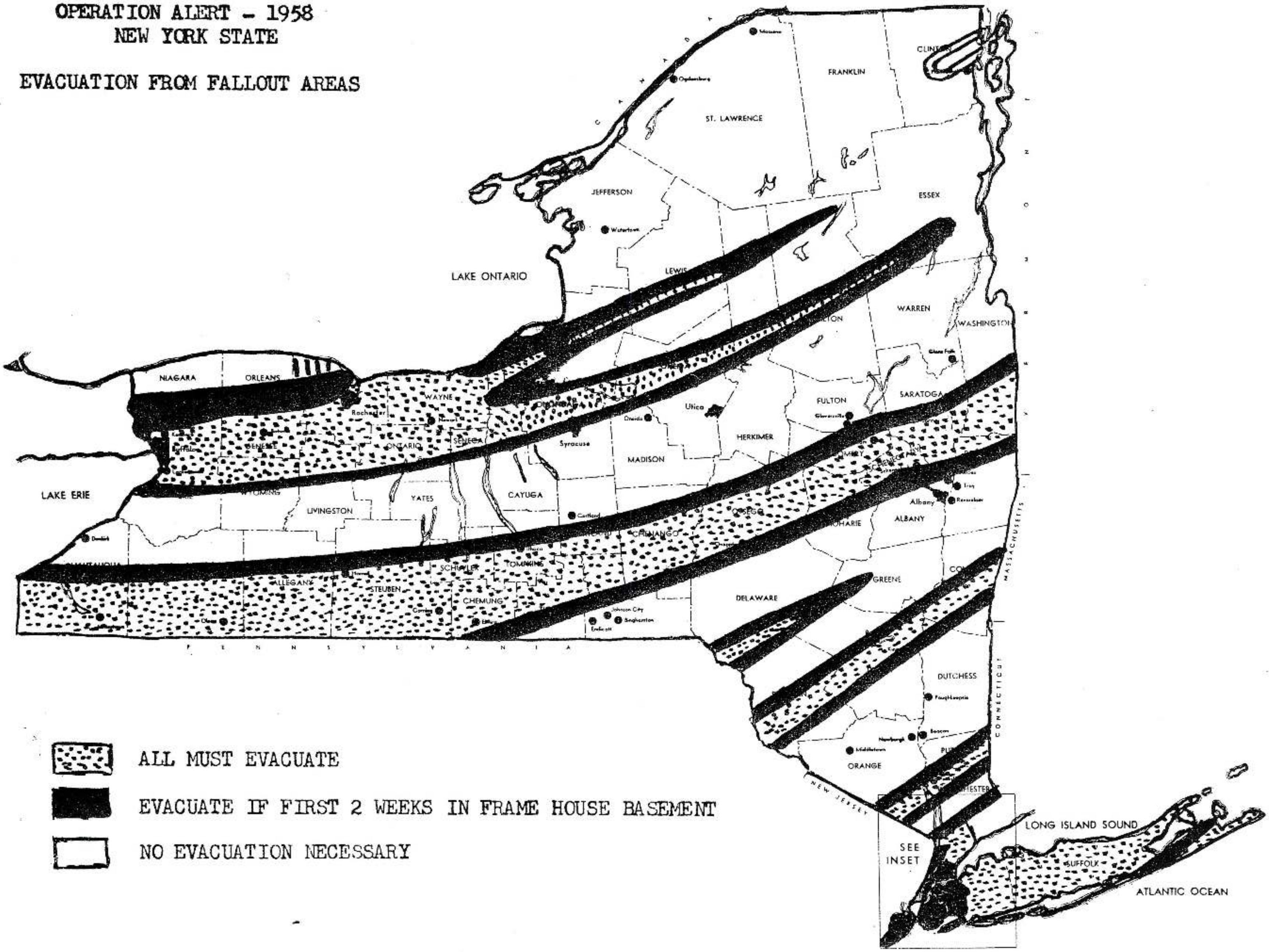
53. Map No. I is an "Evacuation from Fallout Areas Map" based on the attack assumed in Operation Alert - 1958. It shows the areas from which residents who had remained for 14 days in shelter with attenuation factors of 10 and "perfect" (5000 or better) would have had to evacuate to avoid receive 75 r in a month or 200 r in a lifetime.

54. Map No. 2 is a "Return Times After Evacuation Due to Fallout Map." It is also based on the Operation Alert - 1958 attack. It shows the areas to which evacuees could return at various times and avoid 200 r in a lifetime provided that they had spent the first 2 weeks in a framehouse basement (attenuation factor 10), spent 4 hours in travel time, remained for various periods of time in reception areas of 50 r/hr_1, and returned to live normally in their home areas.

55. Map No. 3 illustrates the type of irregular isointensity-isochrone map that might result from a single bomb. It is shown here to demonstrate that fallout effects maps can be plotted on an irregular pattern in the same way that they are plotted on an "idealized one." Two sample fallout effects maps plotted from this isointensity-isochrone map are shown.

OPERATION ALERT - 1958
NEW YORK STATE

EVACUATION FROM FALLOUT AREAS



▨ ALL MUST EVACUATE

■ EVACUATE IF FIRST 2 WEEKS IN FRAME HOUSE BASEMENT

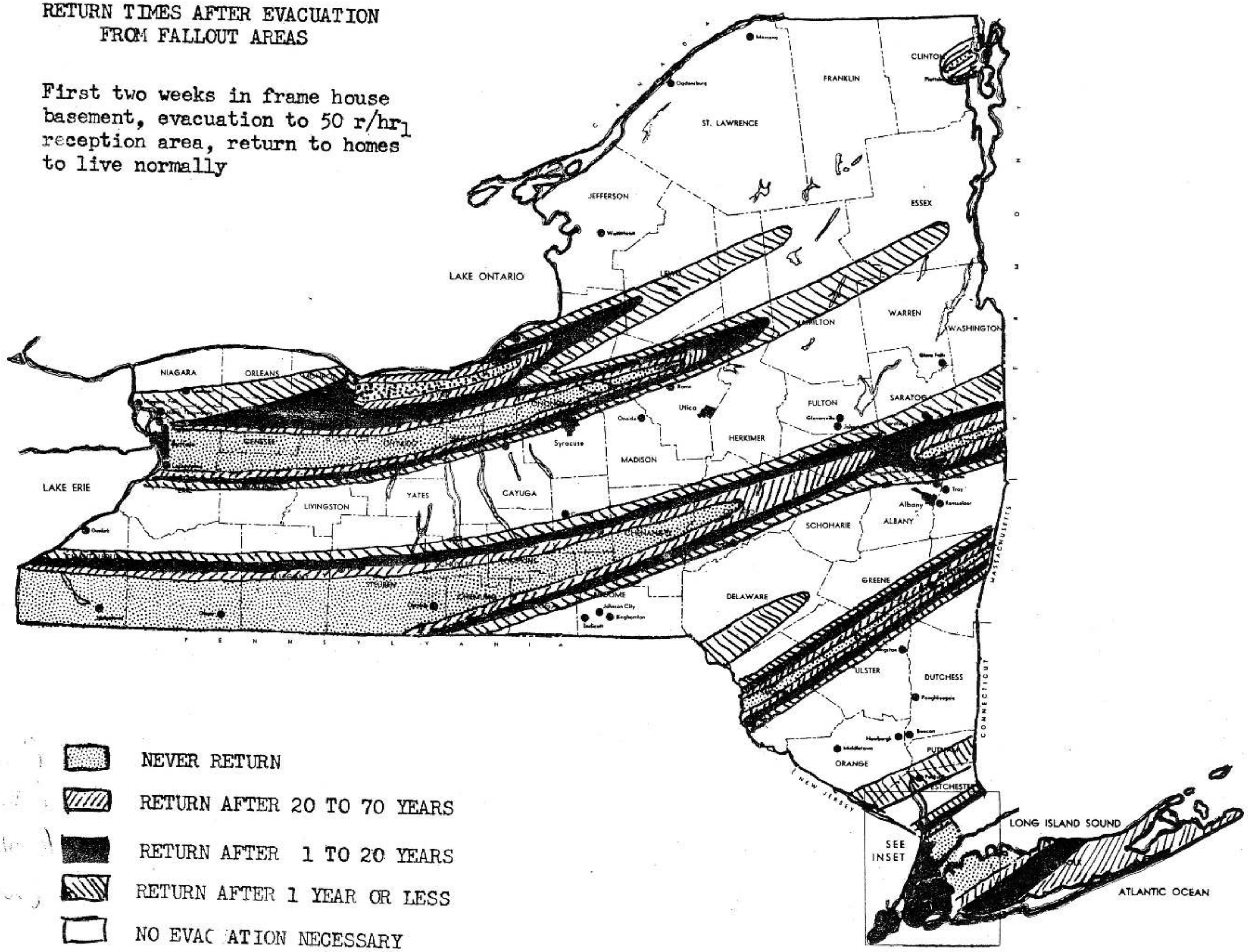
☐ NO EVACUATION NECESSARY

MAP No. 2

OPERATION ALERT - 1958
NEW YORK STATE

RETURN TIMES AFTER EVACUATION FROM FALLOUT AREAS

First two weeks in frame house basement, evacuation to 50 r/hr$_1$ reception area, return to homes to live normally



▒ NEVER RETURN

▨ RETURN AFTER 20 TO 70 YEARS

■ RETURN AFTER 1 TO 20 YEARS

▧ RETURN AFTER 1 YEAR OR LESS

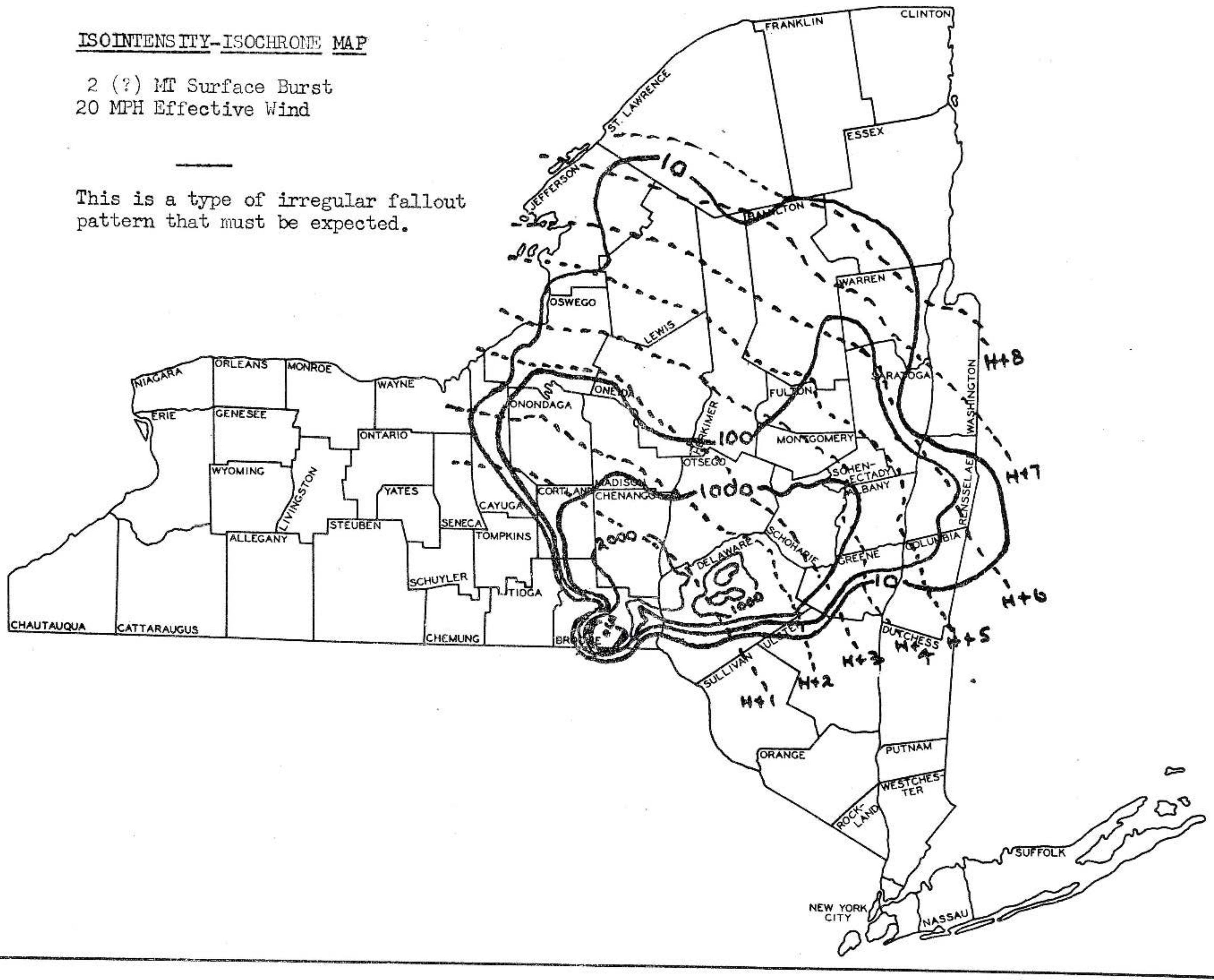
☐ NO EVAC ATION NECESSARY

MAP NO. 3.

ISOINTENSITY-ISOCHRONE MAP

2 (?) MT Surface Burst
20 MPH Effective Wind

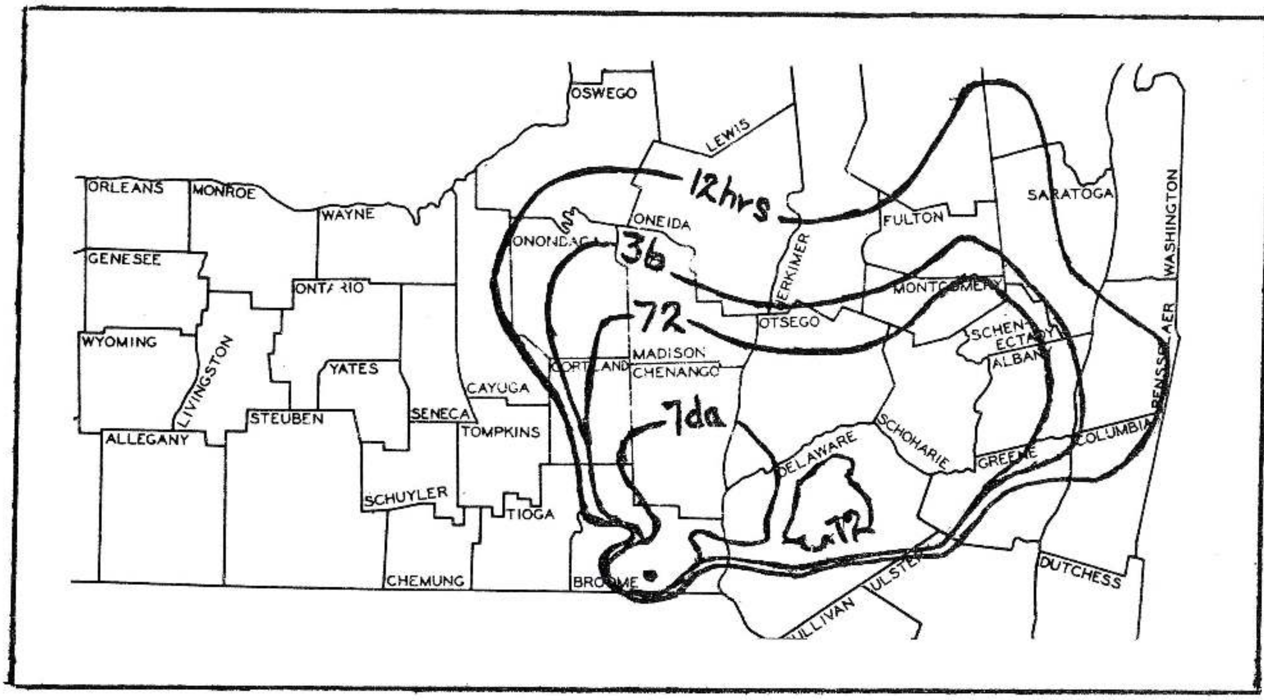
This is a type of irregular fallout pattern that must be expected.



56. The two sample Fallout Effects Map overlays shown below were developed from the irregular isointensity-isochrone pattern of Map No. 3 using figures from tables shown earlier in this paper.

ENTRY-STAY TIMES FALLOUT EFFECTS MAP

- Class "B" CD workers
- Allowable dosage - 25 r
- Length of stay - 8 hours



EVACUATION FROM FALLOUT AREAS

- Evacuation at H + 14 days
- Shelter attenuation factor - 10.